T-TAC 11 Report

Final

1. General Introduction

The committee acknowledges that the previous Transmutation Experimental Facility (TEF), initially split into TEF-T and TEF-P facilities, has evolved beyond its initial scope serving the development of an Accelerator Driven System (ADS) cooled by LBE, and has been revised to become more versatile.

The change of scope has been driven to serve different other thematics with immediate industrial applications, and it includes now 4 main directions:

1) Materials irradiation by high-intensity proton & neutron fields for ADS, J-PARC, fusion and fission reactors
2) Radioisotope (RI) production for medical applications
3) Soft-error testing of semiconductor devices
4) Proton beam application for space technology

Accordingly, a revised conceptual design of a Proton Beam Irradiation Facility (PBIF) has been proposed coupled with a PIE lab.

The proposed program will have a strong synergy with other irradiation facilities presently under refurbishment or re-start in Japan, as the Joyo SFR and water cooled JRR-3 reactors.

The rescoping of the facility notably implicitly postpones the development of advanced fuels and the development of the TEF-P facility.

The ADS Target Test Facility (TEF-T), notably with the implementation of a LBE target which is the core of the previous programme, is also challenged with the development of a new solid target concept cooled by pressurized water. The solid target (made of W cladded with Ta) will have a power of 360 kW (400 MeV, 0.9 mA), as compared to 250 kW baseline with LBE. The main justification put forward is to guarantee higher reliability and availability and therefore to support the industrial involvement on the project (industries as main end-users).

While there is not yet a clear project structure in place, because of the early stage of the rescoping of the facility and its related design, 2 CDRs have been published and serve as a basis of the following steps which have been presented, and which have been used to request funding, and to develop an industrial and user community.

2. Facility Design Update

2.1. Proton Beam Irradiation Facility (PBIF)

Observations

The committee acknowledges the effective workflow adopted to engage the Japanese research community and industry, notably through the organization of dedicated workshops. This approach has successfully clarified user needs and stimulated interest in the proposed irradiation capabilities.

The roadmap clearly highlights the planning of a soft-error irradiation facility, provided that JAXA funding is secured. In this context, JAXA support is recognized as strategic and fundamental for the realization of the facility. The proposed soft-error proton irradiation capability is particularly attractive for radiation testing, owing to the high proton beam energy (up to 400 MeV), which is well suited for single-event effect (SEE) studies.

The committee also notes that the neutron irradiation facility can potentially be used for SEE testing relevant to ground-level applications, further enhancing the versatility of the overall facility concept. Overall, several technical aspects of the proton irradiation concept are already well documented.

The proposed solution for the solid target is based on a well-known technique applied at ISIS at STFC, adopting disks of W cladded with Ta, cooled by pressurized water. The water is pressurized at 200 bar, with a flow rate of 1600 L/min and a pressure loss in to the target of 37 bar.

This will have an impact in term of design of the target, with strong thermal and mechanical loads, as well as strong flow induced vibrations on the disks.

Comments

- The committee considers that the documentation would benefit from additional clarification regarding the interface between the foreseen irradiation facility JAXA and the proposed Proton Beam Irradiation Facility (PBIF). In particular, further clarification of the envisaged level of interaction between the two facilities, including the extent to which the existing JAXA irradiation facility would be affected and the relative positioning of the PBIF beamlines, would help to improve the overall understanding of the proposed layout.
- Further clarification is also encouraged regarding the beam delivery scheme. In particular, it would be useful to explain how low-energy and high-energy proton beams are intended to be transported to the existing space irradiation facility, or whether these beams are foreseen to serve an independent test stand. A clearer description of the operational layout would help to better assess feasibility and flexibility.
- For the neutron irradiation capability, the committee recommends providing a quantitative comparison between the neutron spectra achievable at the facility and standard atmospheric neutron reference spectra used for soft-error testing (e.g. JESD89), such as those available at LANSCE, CHIPIR, or RCNP. This comparison would strengthen the positioning of the facility with respect to established international benchmarks. From a programmatic perspective, the committee advises against mixing the development roadmap of the irradiation facility with that of the hot laboratory PIE. While close coordination between these infrastructures is

necessary, the hot laboratory appears to be a shared J-PARC resource serving multiple facilities rather than being exclusively coupled to the PBIF. A clearer separation of roadmaps would improve readability and strategic coherence.

- The committee further encourages the proton and neutron irradiation facilities to actively pursue internationalization in SEE testing, building on existing collaborations while also fostering new partnerships with international users.
- The committee suggests providing a detailed Technology Readiness Level (TRL) table that distinguishes between elements based on established or proven design concepts and those requiring further technological development, with the latter being supported by a dedicated maturation plan to mitigate risks prior to construction.
- The committee recommends presenting a structured contingency plan addressing scenarios in which not all facility components can be realized simultaneously. In particular, it would be valuable to identify the risks and operational limitations associated with the absence or delay of key elements, such as the hot laboratory, the neutron irradiation facility, or specific proton energy ranges (e.g. low-energy beams). This would support a more robust and transparent facility development strategy.
- The committee recommends to consider for the solid target design Loss of Flow Accident (LOFA) or Loss of Coolant Accident (LOCA) as reference scenarios for its safety assessment, while the station blackout is less relevant because the beam is lost as well along this scenario.
- The maturity of the solid target design is still to be proven and an engineering approach option is suggested considering both LBE, Hg and Water technology for the target.

2.2 Hot Laboratory for PIE

Observations

The committee notes that, with respect to the stated goals and applications of the Proton Beam Irradiation Facility (PBIF), the scope of the proposed Post-Irradiation Examination (PIE) facility at J-PARC appears relatively broad. Based on the current description, it is not fully clear whether all envisaged PIE functionalities are required to support the PBIF use cases.

As indicated in the presentation on Proton Irradiation Facility (“J-PARC needs hot-lab for PIE not only for MLF, but also for other facilities of neutrino and hadron”), the hot laboratory is foreseen as a shared infrastructure serving multiple J-PARC facilities, with only a limited fraction of its capacity effectively allocated to PBIF activities. In this context, the committee considers that the link between the PIE facility and the PBIF project would benefit from further clarification.

Moreover, among the target of the PIE lab is still considered the capabilities to host samples coming from LBE target. Considering the broad scope for the hot cells, the limited volume available, it is suggested to clarify if this target is still needed for the PIE lab.

Comments

- In particular, it is recommended to more clearly delineate whether the hot laboratory is formally part of the PBIF project scope or an independent J-PARC infrastructure from which

PBIF would draw partial usage. From the committee's perspective, a clearer separation of these two aspects would improve transparency and strategic focus.

2.3 Medical Isotopes

Observations

Medical isotope production is presented as one of the four topics to be further developed and integrated in the PBIF and PIE infrastructures. A dedicated workshop, involving industrial partners and more than 100 participants, was organized in October 2025. A roadmap is presented where medical isotope production starts at year 10 from the date of approval of the facility.

Two radionuclides used in nuclear medicine have been singled out, while a 3rd one at a very early research and development maturity level is shown: Mo-99 used as a generator for the most used Tc-99m radionuclide, used in SPECT imaging radiopharmaceutical tracers; Ac-225, an emerging radionuclide for targeted alpha therapy treatments used for research in clinical trials, and expected to reach major market shares in this emerging therapeutic field. Tb-149 combining both PET imaging and targetted alpha therapy properties at a very early R&D stage.

Targetry and station layout inspired from the BLIP facility at BNL (USA) are introduced, while isotope mass separation (CERN) is shown to produce Tb-149 emerging alpha emitter. The target irradiation station is planned upfront of the LBE target layout. The radiochemical process for Ac-225 separation from irradiated thorium target is shown, and the purity grade and yield will depend on the process.

Production cross sections have been measured and computed for a range of accelerator materials. For Mo-99 production, different production paths and irradiation station layouts are considered, namely direct proton irradiation or fast neutron activation. Cross sections were measured for some configurations. This leads to complementary and significant production capacity, complementing the JRR-3 production capacity for a domestic production of Mo-99.

Comments

- Medical isotope production is developed in Japan across a network of nuclear reactors, accelerators such as cyclotrons at universities, and in accelerator centers such as RIKEN with ion accelerators. Interactions with these different centers should be pursued to best position the PITF facility in the Japanese medical isotope production landscape.
- The landscape of medical isotope needs is fast evolving, with emerging radionuclides used in the therapeutic field emerging on a 10-years time scale. Thus Ac-225 which is seen emerging may become at a maturity stage soon, Tb-161 has now emerged in Europe, or At-211 could become the next therapeutic candidate. These radionuclides are not considered yet in the scope of the facility. A slightly increased portfolio should therefore be considered for the medical Isotopes production.
- To maximise the versatility and unique potential of PITF in medical isotope production, the 3 elements should be integrated and kept, if funding would become available: a direct proton irradiation station, a fast neutron irradiation station, and an offline isotope separator. The combination of the three will provide a competitive position of PITF, while staging and moderate financial extra costs would result. Space reservation should be accommodated accordingly in the facility layout.

- The project team should both investigate if research radionuclides (low technological readiness level TRL) or industrial supply should be followed up (high TRL), as it would impact to a large extend the facility layout, such as GMP constraints, and the related operation mode, such as constant and guaranteed supply scheduling.

2.4 Application to Space Strategy Fund

Observations

The committee acknowledges that the proposal submitted to JAXA is very well positioned with respect to the objectives of the Space Strategy Fund and expresses its hope that the requested funding will be secured. The proposed scope is highly relevant for the Japanese space community and directly addresses the recognized need for increased access to proton irradiation beam time, particularly for low-risk, low-cost space missions, typically in Low Earth Orbit (LEO) but not limited to it.

The facility is well aligned with the two main goals of the call:
(1) reducing schedule and cost by providing increased beam-time availability
(2) offering a radiation testing facility that meets the technical criteria defined in the call

The availability of high-energy proton beams, including energies beyond 200 MeV, is considered a strong asset. The proposed implementation of the facility within the linac tunnel is regarded as an appropriate and economically viable solution. The possible beam operation modes are generally well described, and the overall beam parameters (flux, beam size) are within the envelope of comparable international facilities.

The committee further acknowledges the interest in offering a wide range of proton energies. In particular, energies above 100 MeV are recognized as highly relevant for saturated cross-section measurements in SEE testing. Lower energy ranges are also potentially useful, notably for instrumentation calibration or displacement damage studies, provided that adequate simulations and benchmark data are available to properly manage energy spread effects.

Comments

- Building on the strong alignment of the proposal with the Space Strategy Fund objectives, the committee considers that the operational concept would benefit from a clearer prioritization of beam usage modes. In particular, the committee recommends focusing on parallel beam operation schemes, as these maximize effective beam time and provide greater flexibility for user scheduling.
- At the same time, the committee notes that parasitic operation in a parallel-use configuration may impose constraints on facility access, potentially limiting physical access to once per week. While such access conditions are comparable to those of existing facilities (e.g. CHARM), the committee observes that the PBIF would still operate as a beam facility hosting only one user at a time. In this context, achieving high operational efficiency will be essential.

- To support this objective, the committee strongly encourages the early integration of a high level of automation in facility operation and user handling. This aspect is considered critical and should be addressed during the design and planning phase, as it cannot be efficiently implemented after construction.
- Regarding beam energy coverage, while the scientific interest in lower proton energies is acknowledged, the committee suggests that, if parallel operation at multiple energies proves overly complex, priority be given to high-energy beams (>100 MeV), which are most commonly used for SEE testing under saturated cross-section conditions. Lower energy beams may remain of interest for specific applications, but their implementation should be weighed against operational complexity, particularly in parallel-use scenarios. The committee notes that this limitation does not apply in the case of exclusive beam use.
- The committee recommends clarifying how infrastructure would remain in place and not be removed with the subsequent developments and construction of the PIBF. Infrastructure continuity would further strengthen the proposal's robustness and feasibility.

3. R&D Activities

3.1. LBE Technology Development

Observations

The committee recognises the large knowledge and skills of the team LBE technology. The LBE target seems to be mature enough for the design, construction and operation of a prototype.
JAEA is mastering the technology, including instrumentations, corrosion studies (corrosion in flowing LBE can be managed and it is not jeopardizing the adoption of such technology), impurities management, control and operability.

Comments

- The committee suggests to further implements activities on OLLOCHI and IMMORTAL loop, facilities beyond the state of the art on LBE technology, considering the LBE target as on option for the PBIF.
- Issues related to remote handling and maintenance of the target are not considered to be a showstopper for the LBE target option even though the operation at higher temperature can increase challenges in the availability and reliability.

3.2. Design of superconducting linac for ADS and prototyping a spoke cavity

Observations

Beam loss due to transient beam size caused by space charge compensation build-up has been examined numerically, showing that the loss is below the acceptable limit of 1 W/m.

Beam dynamics in transient chopper fields at the end of the pulse was also studied numerically, showing that the beam tail is short enough to meet the requirement for the measurement of reactor subcriticality.

In response to the T-TAC10's comment, the procedure for increasing the beam power to its nominal value was discussed with the reactor team and defined so that the pulse length is increased by 0.5 % every 100 s while maintaining the nominal peak beam current and a repetition rate of 50 Hz, in order to avoid thermal stress on the reactor structure and to ensure integrity of the beam windows.

A beam operation strategy for accelerator commissioning is proposed, where the beam power is adjusted by means of the pulse length and repetition rate while maintaining the nominal peak beam current.

In response to the T-TAC10's comment, methods for rapid beam recovery after a beam trip are being developed in collaboration with other facilities using superconducting linacs.

A reduced scale linac (1 GeV, 10 mA) is proposed as a step toward the full-scale ADS linac (1.5 GeV, 20 mA).

Following the T-TAC10's recommendation, a design report of the reduced scale linac has been completed and is under printing. A design report of the full-scale ADS linac is in the process of writing.

The production of a prototype spoke cavity is continued as per the T-TAC10's recommendation. In FY2024, assembly and welding were conducted, followed by buffered chemical polishing in FY2025. A vacuum heat-treatment is planned in February 2026.

Comments

- T-TAC10's comments and recommendations have been appropriately responded.
- The committee appreciates that intensive numerical studies were conducted to evaluate beam losses and length of beam tail due to transient beam behaviour caused by the chopper. The committee encourages comparison with experiments in other facilities to verify the numerical methods.
- The committee acknowledges that compatibility with the reactor side in ramping up the beam power is considered appropriately.
- There is a concern about the beam operation strategy. What is proposed is to maintain the nominal peak beam current even at the early stage of beam commissioning, in high contrast with practices in other facilities having as low peak beam current as practicable during tuning process of superconducting cavities.
- The committee acknowledges that the production of the prototype spoke cavity is progressing steadily.

3.3. Neutronics experiments

Observations

The construction of the critical assembly in the TEF-P, originally planned, has been removed from the current plan. The main reason is that the nuclear fuel planned for use in the critical assembly was returned to the United States. This decision means that the integral experiments required to improve the accuracy of nuclear data for ADS research cannot be conducted, implying a delay in ADS research.

Determination of different cross section data and extrapolation using newly available artificial intelligence AI-supported numerical modelling is presented. The work has progressed with the determination of different new excitation functions for a number of key material elements for accelerators.

Comments

- While clear progress is shown, often nuclear data must be determined with enriched targets, and it was not clear from the presentation to what extend data from natural elements are completed with enriched targets.
- Data already produced should be published beyond that foreseen as J-PARC technical report.
- In the discussion regarding neutron nuclear data required for ADS, it was explained that while differential nuclear data has sufficient accuracy, the accuracy of integral data is still not adequate. The TEF-P facility, included in the initial plan, was intended to conduct integral experiments for this purpose. Thus, it is necessary to clearly demonstrate how the accuracy of integral data will be improved without TEF-P.

4. General Conclusion

- The committee recognizes the high-level value of the work performed at J-PARC in conceptualizing the PBIF and PIE-Lab infrastructures with 2 Conceptual Design Reports, the necessity to move in a direction able to reduce the time-to-market of the research infrastructure to get industries involved as end-users.
- The committee is not able to provide feedback on the achievement of such goal because the availability of staff, resources and budget is not properly depicted and a clear roadmap is only partially reported.
- The committee recognizes some unique features of the foreseen PBIF in terms of ADS testing, medical radionuclide production and SEE electronics testing.
- The committee recommends to separate out the PBIF and PIE-Lab roadmaps, and to define the different phases able to serve the 4 areas according to the progress in collecting funding.
- The committee suggests to elaborate an early business plan, coupled with some option-engineering studies on some few relevant blocks (e.g. target and PIE lab) to proceed along the project implementation.
- In its current form, the project demonstrates the capacity to deliver tangible impact in the short term, particularly through irradiation services as described in the JAXA strategic funding

for space applications, while preserving the flexibility required to accommodate longer-term developments. This balance between near-term usability and future scalability is considered a key strength of the revised concept. Among the four identified application pillars, the proton irradiation facility for soft-error (SEE) testing clearly stands out in terms of maturity.

- It is highly recommended to elaborate on the operation scenarios of the facilities, and to elaborate on the development of the subsequent phases of the PBIF while the JAXA funded part would serve as a building block for the full facility, and see on the suitability to serve the potential industrial stakeholders and exploit the infrastructures in an optimal way.
- The RI production for medical applications should elaborate on the implementation of a proton irradiation, neutron irradiation and mass separation separate modules.
- An engineering-loaded decision of developing a LBE or solid target should be organized to reallocate properly the limited resources of the division.

Annexes

Mission of T-TAC

To advise primarily to the following items,

• adequateness of the facility concept for achieving the purpose of the proton beam irradiation facility*, namely, the use of proton beam to meet versatile needs

and

• direction and technical aspect of R&D activities on high-power accelerator, proton beam and target technologies for the ADS development.

In addition to the recurrent request described in the mission,

• T-TAC in this year is especially asked to advise on the procedure for developing the design of the proton beam irradiation facility.

T-TAC committee members

T-TAC committee members for FY2024-2026 (renewed)

Name	Affiliation	Field cont.
Thierry STORA (chair)	CERN	RI production, Lead-bismuth tech.
Mariano TARANTINO (new)	ENEA	Lead-bismuth tech.
Salvatore DANZECA (new)	CERN	Soft error
Hiromitsu HABA (new)	RIKEN	RI production (absent)
Tatsuya KATABUCHI (new)	Institute of Science Tokyo	Neutronics (1 day)
Kai MASUDA (new)	QST	Accelerator